PATENT SPECIFICATION

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647,678

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PROVISIONAL SPECIFICATION

Improvements in and relating to Plate Heat Exchangers

We, THE ENGLISH ELECTRIC COMPANY LIMITED, a British Company, of Queens House, 28, Kingsway, London, W.C.2, do hereby declare the nature of this invention to be as follows:—

The invention relates to plate type heat exchangers for heat exchange between gaseous fluids in general, and without prejudice to this general applicability, in particular to heat exchangers for use in gas turbine plant, such as for the heat exchange between the exhaust gases of a gas turbine and the compressed air fed into its combustion chambers.

Amongst the objects of heat exchangers of the kind referred to, both in general and in particular, are of special importance:—

High thermal efficiency i.e. the ratio of heat transferred from one fluid to the other to the heat which can, theoretically, be transferred.

High mechanical efficiency i.e. a low pressure drop in either or both passes.

Freedom from stresses due to differential thermal expansion.

For mobile plants the following objects are of equal importance:—

Small requirement of space, particularly in a dimension across the direction of movement.

Low weight.

A compromise between these various requirments will have to be reached, and other subsidiary requirements will come into consideration according to the special case of application, so as to achieve an overall-optimum.

According to the invention a plate type heat exchanger is provided wherein for the one of the heat exchanging fluids straight-through channels, and for the other one of the heat exchanging fluid ducts with lateral entrances and exits and intermediate portions parallel to said channels are arranged between adjacent identical plates.

Preferably the straight-through channels are separated from one another while the ducts having the lateral entrances and exits form continuous spaces.

The plates for a heat exchanger according to the invention preferably have parallel corrugations or grooves of uniform cross section arranged at a uniform pitch. By making these grooves trapezium shaped and by reversing the one of two adjacent plates relatively to the other by turning it about an axis in its plane perpendicular to the direction of said grooves, the pair of adjacent plates thus formed encloses channels of hexagonal cross section between one another.

Between adjacent pairs of such plates continuous duct spaces are formed having a cross section with trapezium-shaped enlargements on each side reaching between the hexagonal shaped channels enclosed within the adjacent pair of plates on each side.

Preferably the groove near one edge of the plates is arranged at a distance therefrom which is smaller than the pitch between the grooves. When alternating pairs composed of such plates are turned about an axis perpendicular to their plane or about an axis parallel to their grooves and kept registering with their outlines, staggering of the channels in adjacent pairs of plates is achieved, and the trapezium shaped enlargements of the continuous duct spaces between adjacent pairs of plates on the two sides of such duct spaces are also staggered. This arrangement improves the heat transfer from the one fluid to the other, since the enlargements of the continuous duct spaces are then with their broad open bases facing the walls parallel to the planes of the plates of the channels for the other medium.

The plates of one pair are brazed, or when for use at the high temperatures occurring in heat exchangers for gas turbine plant, preferably welded together along the contacting strips between their grooves. If the two heat exchanging fluids are at different pressures, the continuous duct spaces between the pairs of plates are exposed to the higher pressure, and the separate ducts enclosed by each pair to the lower pressure whereby the seams between them are relieved from tensile stresses.

Moreover the opposite plates of adjacent pairs are to be brazed or better welded along their ends, i.e. perpendicular to the channels, in order to close the continuous duct spaces there.

In the case of a heat exchanger where the flow of the heat exchanging fluids is to be mainly parallel, the gaps between the edges of the pairs of plates parallel to the channels must be closed laterally over the central part of their length, preferably by a baffle connected to the outer structure of the heat exchanger but not directly to the plate edges themselves.

Means for keeping the pairs of plates properly spaced are also provided, preferably in the form of racks fitting closely into the intervals between the lateral and/or endwise edges or seams.

In a typical application to gas turbine plant, the heat exchanger is for example used for heat exchange between hot exhaust gases of approximately atmospheric pressure and compressed air for the supply of the combustion chamber or chambers of the gas turbine. In this case in a heat exchanger according to the invention the exhaust is preferably conducted through the straight-through channels, and the compressed air through the continuous intermediate spaces.

This arrangement allows to achieve a smaller pressure drop on the exhaust side in the straight-through channels then on the compressed air side where within the spaces between plate pairs change of direction occurs from the lateral entrance to the intermediate portion which is passed by the air preferably in countercurrent to the exhaust gas stream in the channels and again from said intermediate portion to the lateral exit, the length of the lateral entrances and exits also being limited by the requirement to keep the straight intermediate portion as long as possible.

The requirement of limiting the dimension of the lateral entrances and exits in the direction of the channels while not unduly restricting their cross section is met by a preferred form of the plates, according to which the grooves of the plates are shallower nearer their ends, i.e. in the region of the lateral entrances and exits, than in the main portions thus gaining some width for the continuous duct spaces in these regions at the expense of the straight-through channels. Now a pressure drop on the high pressure side of a gas turbine plant affects the overall efficiency thereof less than a pressure drop on the low pressure side, and in order to keep these restrictions of the straight-through channels at a minimum while at the same time enlarging the cross section of the entrances and exits as far as possible, the latter are arranged at both sides of the plates, and two or more banks of heat exchanger plates are arranged side by side, so as to multiply the number of entrance and exit openings.

Dated this 16th day of June, 1948.

L. B. SHUFFREY.

Agent for the Applicants.

COMPLETE SPECIFICATION

Improvements in and relating to Plate Heat Exchangers

We THE ENGLISH ELECTRIC COMPANY LIMITED, a British Company, of Queens House, 28, Kingsway, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to plate type heat exchangers for heat exchange between gaseous fluids in general, and without prejudice to this general applicability, in particular to heat exchangers for use in gas turbine plant, such as for the heat exchange between the exhaust gases of a gas turbine and the compressed air fed into its combustion chambers.

According to the invention a plate type heat exchanger comprises identical plates having parallel corrugations, which plates are alternately reversed so as to form plate sandwiches each comprising a pair of juxtaposed plates enclosing separate longitudinal channels and wherein consecutive plate sandwiches are spaced apart so as to leave continuous duct spaces between one another which are sealed at the ends of the length and closed laterally at the centre portion of the plates but are left open laterally adjacent these ends.

A preferred form of heat exchanger according to the invention has plates with

corrugations of equal cross section spaced at uniform pitch except the last corrugation adjacent the one longitudinal edge of the plate, which corrugation is of a different width and is arranged with its centre line at a different distance from the said edge than the centre line of the last corrugation adjacent the other longitudinal edge of the plate is from that edge, and the said plate sandwiches are formed by reversing alternate plates about an axis parallel to the planes of the plates and transverse to the corrugations, and wherein alternate plate sandwiches are reversed about an axis parallel to the corrugations or perpendicular to the planes of the plates whereby the separate closed channels within consecutive plate sandwiches are staggered with respect to one another.

These plate sandwiches registering in outline with one another form a bank having straight-through channels enclosed within each individual plate sandwich but with the continuous duct spaces between adjacent sandwiches left laterally open adjacent the ends of the said plates so as to form lateral entrance and exit openings of the said spaces, and sealed at the end edges thereof between adjacent sandwiches and closed laterally in their central portion by flat plates on both sides of the bank of sandwiches, said plates forming, for example, part of a casing containing the bank of sandwiches and lying flush with the longitudinal edges of the said sandwiches. These entrance and exit openings may be made wider than the distance between the central portions of said plate sandwiches if desired. The lateral openings on each side of the bank of plate sandwiches adjacent the one end thereof are connected to an entrance manifold, and the lateral openings on each side of the said bank adjacent the other end of said plate sandwiches are connected to an exit manifold, the two entrance manifolds and the two exit manifolds, respectively, being preferably in connection with one another at a front end of the said bank.

The straight-through channels will offer in general less resistance and consequently cause a smaller pressure drop than the continuous duct spaces.

Preferably these straight-through channels form therefore the hot pass of the heat exchanger, for example, for the exhaust gases of a gas turbine, while the continuous duct spaces from the cold pass, for example for the air delivered from the compressor to the combustion chamber of a gas turbine, so that the smaller pressure drop occurs on the exhaust side of the gas turbine where it affects the overall efficiency of the gas turbine compressor set less than it would on the high pressure side.

In order to be better understood and readily carried into effect, the invention will now be described by way of example with reference to the accompanying drawings of which:

Fig. 1 is a broken-off part elevation of consecutive pairs of plates of a preferred embodiment of the invention.

Fig. 2 is a corresponding plan view, partly in top view and partly in section on the lines A—A and B—B, respectively, of Fig. 1.

Fig. 3 is a side elevation to Fig. 1 partly in section on line C—C and partly as viewed in the direction of the arrows D—D of Fig. 1.

Fig. 4 is a side elevation in section on line E—E of Fig. 1.

Fig. 5 is an isometric part view of two consecutive pairs of plates.

Referring now to Figs. 1 to 4, each plate 1 is longitudinally corrugated to form parallel grooves 2 of trapezium shaped cross section arranged at a pitch p one from another (Fig. 2). The groove nearest to the one longitudinal edge of the plate is at half the said pitch ($p/2$) from that edge and the groove nearest the other longitudinal edge is at a quarter the said pitch ($p/4$) from that edge. The latter groove is of reduced width.

Two plates reversed with respect to one another about an axis parallel to their own planes and perpendicular to the longitudinal direction of said grooves form a pair or sandwich of plates 1a enclosing between themselves hexagonal channels 3 of a uniform size except the channel 3^1 adjacent to one of their longitudinal edges which is of reduced size.

These plate sandwiches are preferably resistance welded at the contacting strips 4 between adjacent channels, and are welded at the edges 5.

By reversing alternate plate sandwiches about an axis parallel to the grooves or perpendicular to the plane of the plates the pattern shown in Fig. 2 is obtained according to which the channels 3 in adjacent pairs or sandwiches are staggered one half pitch ($p/2$).

The cross section of the continuous spaces 6 between adjacent plate sandwiches has lateral projections 7 between adjacent channels which projections, being complementary to the trapezium shaped grooves 2, are themselves trapezium shaped.

By the staggering of the channels 3, these projections 7, too, are staggered, and made to face with their large open bases the flat portion of the adjacent plate in the middle of each channel.

When the channels 3 and the duct spaces 6, 7 are passed by the two heat exchanging fluids in countercurrent in the central

portion of the plates, the most favourable flow and heat exchange conditions are obtained.

At their transverse edges 8 (upper edge, Figs. 1—4 and lower edge, Fig. 5) the opposite plates of adjacent plate sandwiches are welded together so as to close the duct spaces 6, 7 there, while leaving the channels 3, 3^1 open (Figs. 3 and 4).

Adjacent the sealed transverse edges 8 the duct spaces 6 are enlarged so as to form entrances *6a* (Figs. 3 and 4) and similar exits (not shown). These enlargements are achieved by reducing the depth of the grooves 2 in the region of section A—A (Figs. 1—4) to that of shallower grooves *2a* resulting in somewhat [redacted] channel sections *3a* in this region.

Adjacent sandwiches of plates are spaced in plan by means of racks or combs 9 engaging their longitudinal edges 5 near their ends. The racks 9 are eventually welded to the plate sandwiches (Figs. 1 and 2).

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A plate type heat exchanger wherein identical plates having parallel corrugations are alternately reversed so as to form plate sandwiches each comprising a pair of juxtaposed plates enclosing separate longitudinal channels and wherein consecutive plate sandwiches are spaced apart so as to leave continuous duct spaces between one another which are sealed at the end of the length and closed laterally at the centre portion of the plates but are left open laterally adjacent these ends.

2. A plate type heat exchanger as claimed in Claim 1 having plates with corrugations of equal cross section spaced at uniform pitch except the last corrugation adjacent the one longitudinal edge of the plate which is of a different width and is arranged with its centre line at a different distance from the said edge than the last corrugation adjacent the other longitudinal edge of the plate is from that edge, wherein the said plate sandwiches are formed by reversing alternate plates about an axis parallel to the planes of the plates and transverse to the corrugations. and wherein alternate plate sandwiches are reversed about an axis parallel to the corrugations or perpendicular to the planes of the plates whereby the separate closed channels within consecutive plate sandwiches are staggered with respect to one another.

3. A plate type heat exchanger as claimed in Claim 2 wherein the centre line of the corrugation of reduced width is at a quarter of the pitch from its adjacent longitudinal plate edge, while the centre line of the corrugation of ordinary width adjacent the other longitudinal plate edge is at one half of the pitch therefrom.

4. A plate type heat exchanger as claimed in Claim 2 wherein the corrugations are of a trapezium shaped cross section open at the broad base.

5. A plate type heat exchanger as claimed in Claim 1 substantially as described with reference to the accompanying drawings.

6. A plate for a heat exchanger as claimed in Claim 1 substantially as described with reference to the accompanying drawings.

7. A plate sandwich for a heat exchanger as claimed in Claim 1 substantially as described with reference to the accompanying drawings.

Dated this 7th day of May, 1949.

L. B. SHUFFREY,
Agent for the Applicants.

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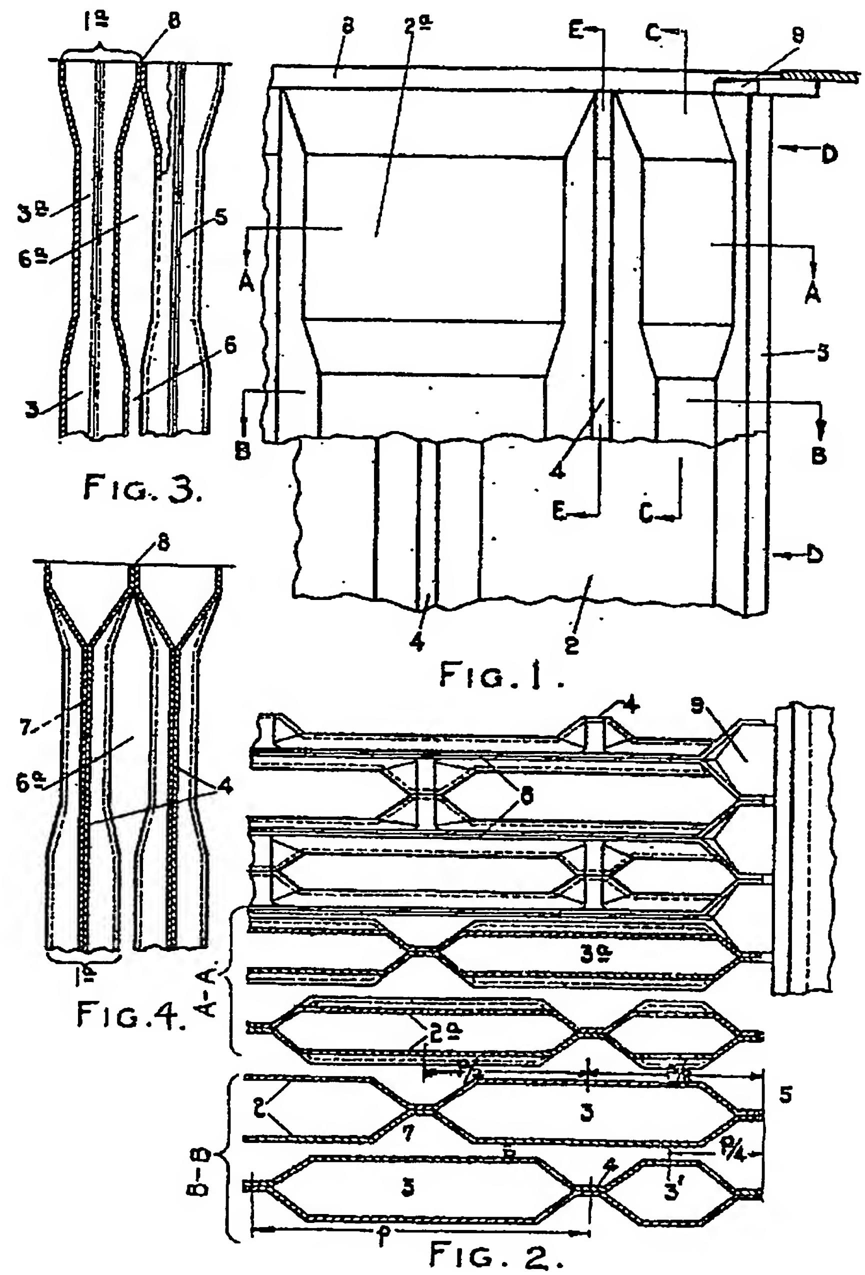
SHEET 1



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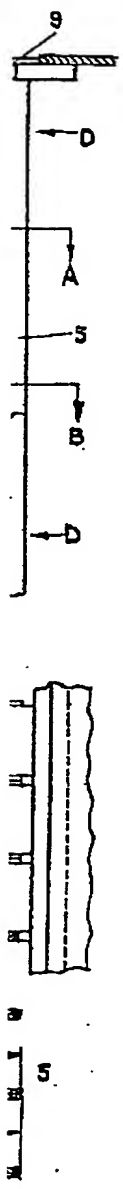
2 SHEETS

SHEET 1



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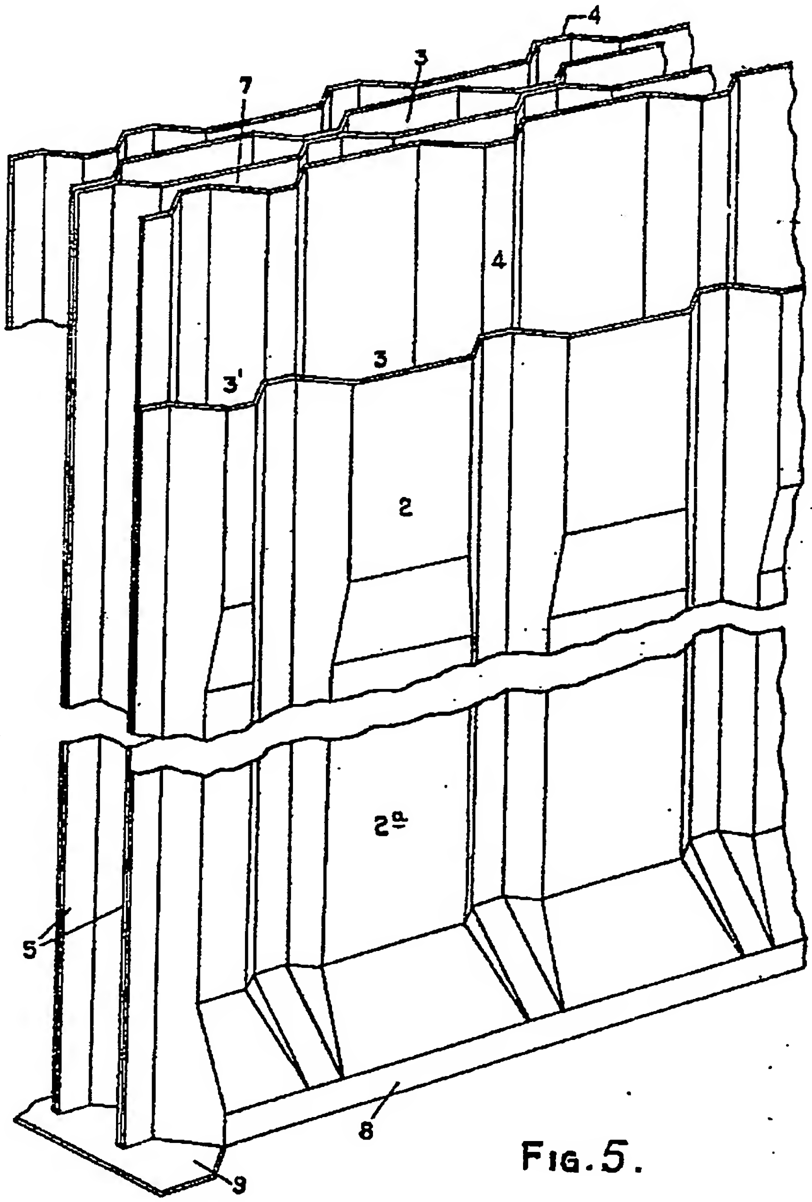

FIG. 5.

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2 SHEETS

SHEET 1

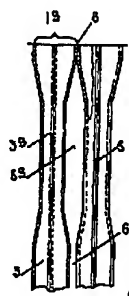

FIG. 3.

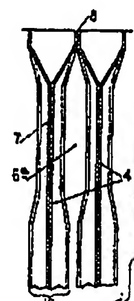

FIG. 4.

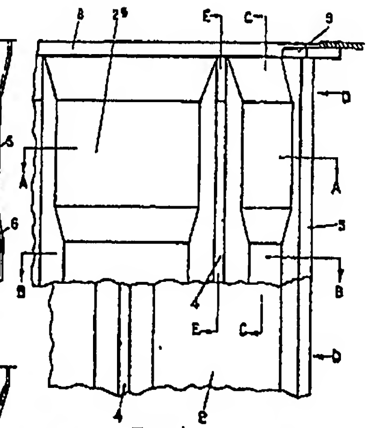

FIG. 1.

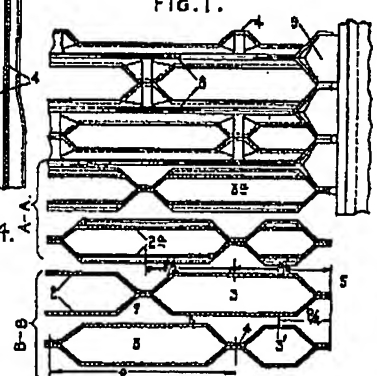

FIG. 2.

SHEET 2

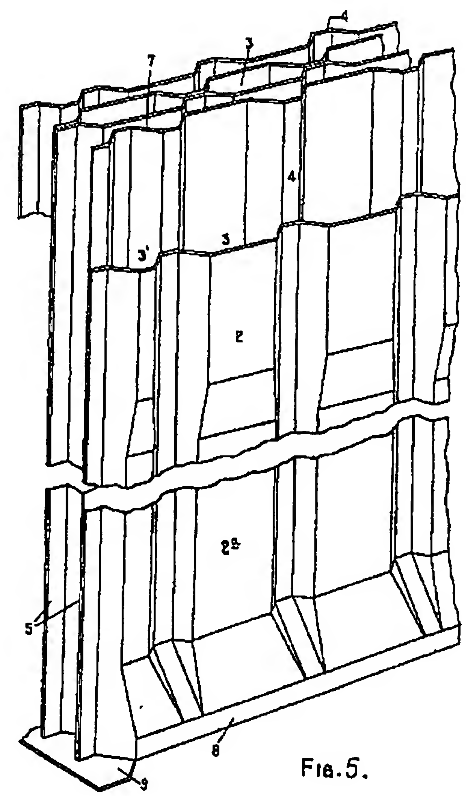

FIG. 5.

[This Drawing is a reproduction of the Original on a reduced scale]

H.M.S.O.(Ty.P.)